REMARKS

In the amendments above, Claims 1-4 and 34 have been cancelled, Claims 5-32, 35-45, and 49 have been amended, and new Claims 62 to 67 have been added to more particularly point out and distinctly claim Applicants' invention.

Claims 2-32, 34-40, 42, 44, and 45 have been rejected under 35 U.S.C. §112, second paragraph, and Claim 39 has been objected to. The Examiner's attention is directed to the amendments to the claims above, which are believed to overcome this rejection and objection.

Claims 1-7, 11, 20, and have rejected under 35 U.S.C. 102(b) as being anticipated by Ayers et al., U.S. Patent No. 5,405,375 ("Ayers"). The Examiner maintains that Ayers is capable of meeting the functional use recitations presented in the claims.

Claims 1-8, 11, 12, 19, 20, 28 and 34-45 have been rejected under 35 U.S.C. 102(e) as being anticipated by Yang et al., U.S. Patent No. 5,824,030 ("Yang"). The Examiner maintains that Yang is capable of meeting the functional use recitations presented in the claims.

Claims 1-12, 19, 20, 32, 34-39 and 41-45 have been rejected under 35 U.S.C. 102(e) as being anticipated by Littmann et al., U.S. Patent No. 5,957,842 ("Littmann"). The Examiner maintains that Littmann is capable of meeting the functional use recitations presented in the claims.

Claims 1-3, 11, 28-32, and 34-45 have been rejected under 35 U.S.C. 102(b) as being anticipated by Swoyer, U.S. Patent No. 5,824,030 ("Swoyer"). The Examiner maintains that Swoyer is capable of meeting the functional use recitations presented in the claims.

Claims 1-6, 11-13, 15-17, 19-21, 28, and 34-45 have been rejected under 35 U.S.C. 102(b) as being anticipated by Kroll et al., U.S. Patent No.55,265,623 ("Kroll"). The Examiner maintains that Kroll is capable of meeting the functional use recitations presented in the claims.

Claims 1-7, 11-13, 15, 19, 21, 28 and 34-45 have been rejected under 35 U.S.C. 102(b) as being anticipated by Pless et al., U.S. Patent No. 5,456,706 ("Pless"). The Examiner maintains that Pless is capable of meeting the functional use recitations presented in the claims.

Claims 1-6, 11-13, 15, 19, 21, 28 and 34-45 have been rejected under 35 U.S.C. 102(b) as being anticipated by Hoffmann et al., U.S. Patent No. 5,534,022 ("Hoffmann"). The Examiner maintains that Hoffmann is capable of meeting the functional use recitations presented in the claims.

Claims 14 and 18 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Kroll (or Pless or Hoffmann). The Examiner maintains that Kroll (or Pless or Hoffmann) discloses the claimed invention except for the diameter being less than 1.2 mm or the electrode impedance being between 50 and 500 ohms; and that it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the lead having electrodes as taught by Kroll (or Pless or Hoffmann), with the lead diameter being less than 1.2 mm and the electrode impedance being between 50 and 500 ohms since it was known in the art that leads having electrodes use a lead diameter less than 1.2 mm to allow the lead to have a small footprint in the body and/or allow the lead to be placed in the coronary veins and since it was known in the art that leads having electrodes provide the electrode with an impedance between about 50 to about 500 ohms to provide a low impedance lead that will not waste energy of the implantable device.

Claims 22-27 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Kroll (or Pless or Hoffmann or Ayer or Yang or Littmann). The Examiner maintains that Kroll (or Pless or Hoffmann or Ayers or Yang or Littmann) discloses the claimed invention except for the multiple lumens each having a conductor (claim 22), the particulars of the distal connector means comprising a substantially flat terminal member (claim 23), connecting the conductors to the distal connector using laser welding or crimping (claims 24 and 25), the terminal member being titanium (claim 26), and spiraling of the conductors in the lead lumen (claim 27); and that it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the lead having electrodes as taught by Kroll (or Pless or Hoffmann or Ayers or Yang or Littmann), with the lead having multiple lumens with each lumen having a conductor, connection of the conductors to distal connectors using laser welding or crimping, and the spiral conductors in the lumens since it was known in the art that leads having electrodes use multiple lumens, with each lumen having a conductor in the lumen to allow the lead body to have a smaller footprint in the body by not using insulation on each conductor; laser welding or crimping to connect conductors to distal connectors to provide a fast, secure method for the connection of different elements; and to spiral the conductor in the lumen to allow the lead to be more flexible and less resistant to breakage.

The Examiner also maintains that it would have been an obvious matter of design choice to a person of ordinary skill in the art to modify the lead having electrodes as taught by Kroll (or Pless or Hoffmann or Ayers or Yang or littmann) with the particulars of the distal connector means comprising a flat terminal member and the terminal member being titanium, because Applicants have not disclosed that the particulars of the distal connector means comprising a flat terminal member and the terminal member being titanium provides an advantage, is used for a particular purpose, or solves a stated problem; that one of ordinary skill in the art, furthermore, would have expected

Applicants' invention to perform equally well with the connections of the conductors to the connectors as taught by Kroll (or Pless or Hoffmann or Ayers or Yang or Littmann), because it provides a secure connection of the conductors to the connectors and allows sensing or applying a field to take place; and that therefore, it would have been an obvious matter of design choice to modify Kroll (or Pless or Hoffmann or Ayers or Yang or Littmann) to obtain the invention as specified in the claim(s).

Applicants respectfully traverse the above rejections.

The present invention is in the field of leads comprising electrodes that are implanted to provide long-term therapeutic care – a field that appears to be very crowded with devices having similar appearance and function to those of the present invention. The principal distinguishing feature of the device of the present invention is in the type of electric field (i.e., the amount of energy) supplied to the surrounding tissue by the electrodes. It is to be borne in mind throughout the discussion of the relationship of this invention to the prior art that, until the work by the Assignee of the present application described in the references cited below, this energy range was not felt to be useful therapeutically by those skilled in the art, and, therefore, no leads designed to deliver signals in this energy range have been previously described. For this reason alone, any apparatus designed and optimized to supply therapeutic signals having energy in this range is by definition new and inventive. Beyond this fact however, the development of the device of the present invention involved much more than simple straightforward adaptation of presently available devices to the new energy range. A great deal of innovative skill was necessary to balance and optimize the many different and often conflicting demands and factors. Amongst these factors are the selection of the materials, electro-chemical properties, and dimensions of the electrodes as well as requirements and limitations imposed by the intended operating environment of the device as a whole, e.g. dimensions, flexibility, biocompatibility, energy supply, etc. As a specific example of

the many difficulties overcome in inventing the device, a discussion of the principle considerations that were taken into account in determining the appropriate size for the delivery electrodes is given below.

The Present Invention

The invention, as presently defined in the amended claims, is directed to a lead designed to perform both localized sensing and to provide localized therapy based on the results of the return signals from the sensing electrode means.

In the preferred embodiments, the therapy is provided by delivery electrode means that are capable of enabling non-excitatory stimulation of a portion of tissue, such as for example the heart muscle, in response to the results of monitoring or sensing of the activity in essentially the same portion of tissue using the same or other electrodes. In other words, the present invention provides a method and system for the precise delivery of non-excitatory electrical signals to one or a plurality of locations on the cardiac muscle, for example, each of which is synchronized, to the locally sensed intrinsic electrical activity (page 4, lines 19-21).

Other characteristics of the lead of the invention are that it is designed for chronic implantation (pg. 7, line 15), it can be introduced into the left side of the heart through the Coronary Sinus (Fig. 19 and description on pg. 32 also pg. 37, middle paragraph), and its delivery electrodes can produce a pacing or defibrillation stimulus in addition to non-excitatory signals (pg. 31, lines 19-23).

Non-excitatory stimulation of a tissue such as the heart is very different from both pacemaker operation and from defibrillator operation, as clearly shown in WO 97/25098, which was incorporated in the present application (page 2, line 1) by reference thereto. Thus, as described on page 8, line 37, to page 9, line 7, of this reference:

"A pacemaker exerts excitatory electric fields over many cycles, while a defibrillator does not repeat its applied electric field for many cycles, due to the disruptive effect on the defibrillation current on cardiac contraction. In fact, the main effect of the defibrillation current is to reset the synchronization of the heart by forcing a significant percentage of the cardiac tissue into a refractory state. Also, defibrillation currents are several orders of magnitude stronger than pacing currents." (Emphasis added.)

In contrast thereto, in non-excitatory stimulation, "the regular activation of the heart is not disrupted, rather, the activation of the heart is controlled, over a substantial number of cycles, by varying parameters of the reactivity of segments of cardiac muscles cells".

Further, and as described in WO 97/25098, page 9, line 37, to page 10, line 2:

"A non-excitatory signal may cause an existing action potential to change, but it will not cause a propagating action potential, such as those induced by pacemakers. The changes in the action potential may include extension of the plateau duration, extension of the refractory period, shortening of the post-plateau repolarization and other changes in the morphology of the action potential." (Emphasis added.)

Further examples of non-excitatory stimulation are provided in the reference in succeeding sections thereof.

Thus, non-excitatory stimulation is different in purpose and function from either pacing or defibrillation. As described in page 4, line 22, to page 5, line 2, of the present application, "the timing and characteristics of an electrical field that modifies the contractility of the heart and the sensing required for controlling the delivery of the signal

required, are entirely different from any signal applied to the heart for pacing or defibrillating." (Emphasis added.)

In addition to defining non-excitatory signals by the physiological effects such signals produce in tissue, such signals can be described quantitatively in terms of the amount of energy that must be supplied by the delivery electrode means. As described in the present application, in the above referenced PCT publication, and is well known to persons skilled in the art, pacing signals have a relatively low energy, defibrillation signals are on the order of magnitude of 10^5 times greater than pacing signals, and non-excitatory signals typically have an energy on the order of 20-100 times that of pacing signals.

In one embodiment of the invention, the same electrode (a unitary electrode) is used for sensing and for providing the appropriate non-excitatory electric field, the sensing mode and the generation of the electric field being non-simultaneous. In another embodiment, one pair of electrodes in close proximity to each other is provided, one electrode for sensing, and the other for providing the electric field. In yet another embodiment, pairs of electrodes are provided, in each pair one electrode providing the sensing functions in close proximity to the other electrode, which is for providing the non-excitatory electric field. In each case sensing and the generation of an appropriate electrical field are carried out at either the same location or in close proximity, and when there are a plurality of electrodes for sensing and/or providing a field along the lead, these are substantially independent one from the other so that different electric fields may be provided at different locations along the lead. Thus, a lead according to the present invention is adapted for selectively delivering a suitable non-excitatory electric field to at least portion of tissue to achieve a desired change by enabling the sensing and field generation to be performed at the same or very close locations on the lead, and where

applicable by enabling different electric fields to be selectively provided by each corresponding electrode.

The size of the electrodes is one of the critical design features of the invention. To sense the activity at a well-defined localized area, the sensing electrodes must be very small. On the other hand, delivery of signals large enough to produce the desired therapeutic results requires much larger electrodes. For this reason, separate sensing and delivery electrodes are used in most embodiments of the present invention.

The size of the delivery electrode influences the final performance in at least three ways that had to be considered when designing the delivery electrodes of the lead of the invention. Firstly, to insure sufficient robustness to allow for long-term implantation of the electrode, the magnitude of the applied energy and duty cycle must be taken into account when determining the size of the delivery electrode. When an electrode is implanted and activated, a capacitance is created between the electrode and the surrounding tissue. The capacitance depends on the area of the electrode facing the tissue and the material properties of the electrodes and the surrounding electrolyte. If the capacitance rises above a critical value, irreversible electro-chemical processes leading to deterioration of the electrode and electrolysis of the electrolyte takes place. One guiding design principle is that the larger the area of the electrodes, the lower the risk that the critical value will be reached. One of the most important of the material properties of the electrodes affecting the capacitance is the amount of charge per surface area of the electrode, the higher the value of this parameter, the higher the capacitance. The second consideration is that the size of the delivery electrode must be small enough to deliver a signal to the surrounding tissue of sufficient energy density to produce the desired effect. If the area of the electrode is too large, it might never be possible to achieve high enough current densities to produce the desired therapeutic results without using an unacceptably high level of input energy (in which case the energy source (battery) would have an

unacceptably short lifetime making the device as a whole unsuited for long-term implantation). Thirdly, the size of the electrode determines the size of the area and the location at which the signal can be applied. A large electrode will not allow localized therapy and a small electrode will not allow therapies that must be applied simultaneously to large areas of tissue. A large electrode cannot be incorporated into a lead or other delivery means that must be narrow enough and flexible enough to deliver the lead to a location in a narrow lumen or must travel through a narrow, twisted path to get to the implantation site.

To summarize, it can be seen that the design of delivery electrodes that are suitable for meeting the requirements of the present invention is a very complex task. On the one hand, the electrodes should be relatively large to allow for long term application of non-excitatory signals without deterioration and on the other hand they must be small enough to allow localized application of the non-excitatory signal, to enable the lead carrying them to be introduced into the left ventricle by passing through the coronary sinus, and to provide a high enough current density.

From the above, it also can be seen why prior art pacing and defibrillation electrodes are not capable of satisfying the requirements of the present invention. Pacing electrodes are smaller than the delivery electrodes of the invention and deliver a smaller signal. If higher energy is applied to such electrodes to produce non-excitatory signals, then rapid deterioration of the electrode will take place, making it unsuitable for long-term implantation. For this reason, prior art pacing electrodes can not be used to produce the same results as the delivery electrodes of the invention. Defibrillation electrodes are relatively large making them unsuitable for passage through the coronary sinus for insertion in the left ventricle. They also cannot be used to apply a localized signal. More significantly, the large surface area of these electrodes means that a high enough current density cannot be attained to produce non-excitatory signals for a protracted period of

time without depleting the energy source of the device. For this reason, prior art defibrillation electrodes can not be used to produce the same results as the delivery electrodes of the invention.

The prior art

The Examiner cites the following publications as anticipating the present invention or as the basis of obviousness rejections:

i. Yang et al., U.S. Patent No. 5,824,030 teaches a lead for ventricular and atrial sensing or pacing. The distinguishing feature is an outer sheath with windows that allow selection (exposure) of specific atrial electrodes (with optimal spacing for a given patient) from a series of electrodes distributed along the shaft of the lead. The ventricular electrode is a distal tip electrode and the lead is designed for long-term implantation (col. 5, lines 3-10). The lead is designed for placement in the right side of the heart (Figs. 1, 12, 14, 17, 20, and description, e.g., col. 4, line 66). Yang does not teach or suggest that the electrodes of his lead are arranged in associated pairs such that the characteristics of the signal delivered by each of the delivery electrodes is determined a signal from an associated signal electrode. The possibility of delivering non-excitatory signals is not mentioned, and, since the electrodes are designed specifically for pacing or signaling, they are incapable of delivering a signal with enough energy to be non-excitatory.

ii. Ayers et al., U.S. Patent No. 5,405,375 teaches a catheter comprising electrodes for sensing electrical activity of the heart at localized locations and electrodes for defibrillation distributed along the length of the catheter. The catheter is for mapping and not permanent implantation (col. 2, line 5). The sensing and defibrillation electrodes are not distributed in associated pairs, the members of each pair located in close proximity to one another. All of the defibrillation

electrodes are electrically connected and individual electrodes cannot be activated alone to give localized treatment. The catheter has a tip electrode (56, 108). As discussed hereinabove, the defibrillation electrodes of Ayers can not produce non-excitatory signals.

iii. Hoffmann et al., U.S. No. 5,534,022 teaches a lead comprising two types of unitary electrodes the first for sensing/pacing and the second for sensing/defibrillation. The lead is designed for long term implantation in the right side of the heart (figures and abstract) and comprises a tip electrode (44). The production of non- excitatory signals is not discussed in the patent and, as discussed hereinabove, the pacing and defibrillation electrodes of Hoffmann can not produce such signals for a suitable duration of time.

iv. Pless et al., U.S. No. 5,456,706 describes a defibrillation lead for permanent (col. 4, lines 33-34) implantation in the right side of the heart (claim 1). The sensing electrodes are not located in close proximity to the defibrillation electrodes. The lead comprises at least two defibrillation electrodes and optionally pacing electrodes. In all embodiments shown in the figures except for one, the lead comprises a distal tip pacing/sensing electrode. In the one exception, one of the defibrillation electrodes is located at the distal end of the lead. The production of non- excitatory signals is not discussed, and the design of the pacing and defibrillation electrodes does not allow for production of such signals. The electrodes of Pless can not deliver a localized signal.

v. Kroll et al., U.S. No. 5,265,623 describes a defibrillation lead for introduction into the left ventricle of the heart. The lead has a distal tip pacing/sensing electrode and is designed for permanent implantation. The sensing and defibrillation electrodes are not located in close proximity to each other. For the reasons

discussed hereinabove, the electrodes described are not capable of supplying localized non-excitatory signals.

vi. Swoyer, U.S. Patent No. 5,683,445 describes a lead specifically designed for introduction into the left ventricle through the coronary sinus. The delivery electrode is located spaced apart from the distal tip sensing electrode therefore the signal is not delivered to the location from which the sensing signals originate. The electrodes described in Swoyer are not capable of supplying localized non-excitatory signals.

vii. Littmann et al., U.S. Patent No. 5,957,842 describes a sensing guide wire used for diagnostic purposes only. The device in Littmann has none of the characterizing features of the present invention.

Summary and Conclusions

None of the above references cited by the Examiner describes or teaches an electrode capable of delivering non-excitatory signals. None of the above references describes an apparatus having separate sensing electrode means and associated delivery electrode means located in close proximity to one another and distributed along at least part of the length of the lead and control means that use the characteristics of the activity sensed by each of the sensing electrode means as input for determining the individual parameters and sequencing of the electric field to be provided by each of the delivery electrode means. In addition to these general differences between the cited prior art and the present invention, there are many other differences specific to each device. For example, leads comprising electrodes designed for pacing cannot deliver non-excitatory signals for an extended period of time. Also, leads designed for defibrillation are incapable of delivering localized signals. And further, leads having a distal tip electrode

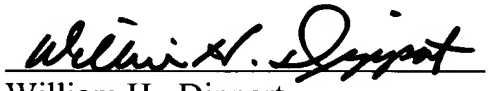
and defibrillation leads cannot pass through narrow and twisting paths such as through the coronary sinus.

In view of all of the above, and especially taking into account the fact that the present invention is directed to providing for the first time an apparatus that is uniquely able to provide a new type of therapeutic signal for modifying the activity of a tissue, Applicants respectfully request that the Examiner review the amendments above and the comments above and then reconsider the bases of the rejections under §§ 102(b), 102(e), and 103(a). It is earnestly believed that these rejections have been overcome and should be withdrawn.

Reconsideration and allowance of all the claims herein are respectfully requested.

Respectfully submitted,

December 1, 2003



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